NeoBiota 58: 33–54 (2020)
doi: 10.3897/neobiota.58.51522
http://neobiota.pensoft.net

RESEARCH ARTICLE

A peer-reviewed open-access journal
NeoBiota
Advancing research on alien species and biological invasions

Perceptions of alien plants and animals and acceptance of control methods among different societal groups

Raphael Höbart[1], Stefan Schindler[2,3], Franz Essl[1]

1 *Division of Conservation Biology, Vegetation and Landscape Ecology, Department of Botany and Biodiversity Research, University Vienna, Rennweg 14, 1030 Vienna, Austria* **2** *Environment Agency Austria, Department of Biodiversity and Nature Conservation, Spittelauer Lände 5, 1090 Vienna, Austria* **3** *Czech University of Life Sciences Prague, Faculty of Environmental Sciences, Community Ecology and Conservation research group, Kamýcká 129, CZ-165 00 Prague 6, Czech Republic*

Corresponding author: Franz Essl (franz.essl@univie.ac.at)

Academic editor: L. Foxcroft | Received 27 February 2020 | Accepted 5 May 2020 | Published 1 July 2020

Citation: Höbart R, Schindler S, Essl F (2020) Perceptions of alien plants and animals and acceptance of control methods among different societal groups. NeoBiota 58: 33–54. https://doi.org/10.3897/neobiota.58.51522

Abstract

Biological invasions are a widespread phenomenon and cause substantial impacts on the natural environment and human livelihoods. Thus, the European Union (EU) recently adopted Regulation No 1143/2014 to limit the negative impacts of invasive alien species (IAS). For implementing IAS management and policies, public support is highly and increasingly important, especially when it comes to charismatic species and lethal methods. Recognising the importance of the interaction of public perception with acceptance of IAS management methods, we used an online survey targeting three different stakeholder groups in Austria to evaluate potential differences in perception of IAS and management methods.

In total, we received 239 completed responses: 20 nature users (farmers, hunters), 91 nature experts (conservationists, biologists) and 128 from the general public. Participants were more likely to accept lethal management methods when it was an IAS. Nature experts' acceptance of IAS management methods was rather similar to those of nature users, while the general public preferred non-lethal methods. Chemical lethal methods (herbicides, poison pellets) received low rates of acceptance throughout all stakeholder groups, although nature users were more open to accept such methods for plants. Most respondents (> 50%) were not aware of the role of the EU in IAS topics nor did they know of the existence of the EU IAS regulation 1143/2014. However, more than 75% of respondents agreed that IAS measures and regulations should be implemented at EU level.

This study shows that knowledge about native versus invasive alien status has an influence on the acceptance of management methods. Nature users may have higher levels of acceptance of lethal methods because they are economically dependent on extracting resources from nature. Invasive alien species regulations on EU level are generally acceptable, but there is low awareness for actions already undertaken EU.

Copyright *Raphael Höbart et al.* This is an open access article distributed under the terms of the Creative Commons Attribution License (CC BY 4.0), which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.

Keywords
EU Regulation 1143/2014, IAS control, management methods acceptance, nature conservation, perception, survey, values

Introduction

Biological invasions are a widespread phenomenon and cause substantial impacts on the natural environment and human livelihoods (Pejchar and Mooney 2009; Vilà et al. 2011). Thus, one of the targets of the EU Biodiversity Strategy 2020 (European Commission 2011) is to "combat invasive species", i.e. to halt – or at least to reduce – the negative impacts caused by biological invasions. To achieve this, "Regulation (EU) No 1143/2014 on the prevention and management of the introduction and spread of invasive alien species [IAS]" was adopted in 2014 (European Parliament 2014).

According to this regulation, "alien species" are defined as any live specimen of a species, subspecies or lower taxon of animals, plants, fungi or micro-organisms introduced outside its natural range; it includes any part, gametes, seeds, eggs or propagules of such species, as well as any hybrids, varieties or breeds that might survive and subsequently reproduce. "Invasive alien species" are those alien species whose introduction or spread threatens or adversely impacts upon biodiversity and related ecosystem services (European Parliament 2014; Essl et al. 2018).

One key component of the EU regulation is the "List of Invasive Alien Species of Union Concern" (Roy et al. 2019). The European Commission and EU member states can propose candidate species for this list. Such candidate species have to undergo a risk assessment and, subsequently, a decision whether to include these species into the list of IAS of EU concern is made by the EU member states. Once approved, the listed species fall in the range of measurements of Regulation no. 1143/2014. Initially, this list contained 23 plant species and 26 animal species (European Commission 2016), but it has been expanded by another 16 species in spring 2019 (European Commission 2019). Generally, there are no specified recommendations for management measures in Regulation no. 1143/2014, but it is stated in Article 19 that "lethal and non-lethal physical, chemical and biological actions aimed at the eradication, population control or containment of a population of an invasive alien species" (European Parliament 2014) should be taken into consideration. Article 25 specifies that IAS management "should be proportional to the impact [of IAS] on the environment" and the operator "should take the necessary measures to spare avoidable pain, distress and suffering of animals during the process". Moreover, "non-lethal methods should be considered and any action taken should minimise the impact on non-targeted species" (European Parliament 2014).

Therefore, the question arises if killing a charismatic animal for conservation purposes is justified and appropriate (Jaric et al. 2020). Scientific and general public opinions can differ tremendously (Bertolino and Genovesi 2003) and public opinion

becomes increasingly important for IAS management (Vaske et al. 2011; Verbrugge et al. 2013; Crowley et al. 2017). A recent example in this context is the Australian feral Brumby horse. In 2018, public pressure led to the termination of scientifically-recommended conservation actions (NSW Government Office of Environment & Heritage 2016; Australian Academy of Science 2018), in this case shooting the feral horses. The government of New South Wales followed the public protesters' and animal rights activists' demand and protected an invasive alien horse (Brumby, *Equus caballus*) (Parliament of New South Wales 2018), although scientific evidence shows that Brumbies threaten habitats and native species (Nimmo and Miller 2007; Worboys and Pulsford 2013; NSW Threatened Species Scientific Committee 2016). A similar situation unfolded in Italy in the late 1990s, when animal rights activists stopped the eradication of a population of invasive grey squirrels (*Sciurus carolinensis*), which is native to eastern North America, by taking the responsible conservation institute to court (Bertolino and Genovesi 2003). These examples raise the question as to what underlies the motivations that cause public opposition to population reduction measures of invasive alien species.

Aesthetic and charismatic species are often used as flagship species for engaging stakeholders, increasing acceptance and promoting conservation programmes (Caro and Girling 2010). Cultural ecosystem services, such as aesthetic appreciation or recreation, are highly valued by people across all societies (WHO 2005). Thus, the (invasive alien) species' appearance might be one of the underlying motives for rejecting or accepting a specific management method. Further, different economic interests, value systems, preferences and biases may affect social perceptions of IAS and of management measures (Kueffer 2017; Kapitza et al. 2019; Shackleton et al. 2019a).

Here, we used an online survey targeted at three stakeholder groups. Participants assessed pairs of IAS included in the EU IAS regulation and native species. By doing so, we addressed the following questions: 1) What are the differences in perceptions of invasive alien plant and animal species and similar native species? 2) What is the level of knowledge in identifying invasive alien and native species? 3) What are the differences in acceptance of different management measures? 4) Which institutions should play stronger roles in IAS management?

Methods

Survey and sampling design

For this research, the non-probability method of self-selective convenience sampling was chosen, i.e. there are no rules for selecting the potential participants (Saunders et al. 2009). In the handbook of web-surveys (Bethlehem and Biffignandi 2012), it is defined that "elements are drawn for such a sample because of their convenient accessibility or proximity to the researcher. Convenience sampling is fast, simple and cheap. Self-selection samples can be considered a form of convenience sampling"

(Bethlehem and Biffignandi 2012). For a survey that includes large target groups, this is considered to be an appropriate approach. Our approach was partly self-selective, because it was distributed via pre-selected media channels (e.g. Facebook-posting, E-mail).

An additional advantage of convenience sampling is that it facilitates reaching out to participants from stakeholder groups that are otherwise difficult to reach (Saunders et al. 2009), for example, via selected media. The main disadvantages of this method is that results cannot easily be generalised to the entire stakeholder group (Bethlehem and Biffignandi 2012; Raab-Steiner and Benesch 2018; Schnell et al. 2018). In addition, response rates cannot be calculated accurately (Bethlehem and Biffignandi 2012). However, the demographic data of the participants are helpful for interpreting the results and for identifying potential biases in participation.

We designed an online survey (in German; see Suppl. material 1: Text S1 for German and Suppl. material 1: Text S2 for translated English version) which was circulated widely to potential participants in Austria. The online survey used species pairs consisting of native – invasive alien species (Figure 1). The survey had nine questions that referred to these species pairs and which dealt with i) perception, ii) management measures, iii) knowledge on native/invasive alien status, iv) relevance of invasive alien species to Austrian biodiversity and environmental management and iv) knowledge and performance of EU IAS policies. A Likert-type-scale approach was chosen for all questions, which captured the response of the recipients depending on the dis-/agreement to the respective statement (Likert 1932; Raab-Steiner and Benesch 2018).

Study species selection and description

A total of four species pairs (thus eight species in total) consisting of a native and an invasive alien species were selected. We used two mammal species pairs and two vascular plant species pairs. The four invasive alien species are included in the "EU List of IAS of Union Concern" (European Commission 2016). The invasive alien species were paired with species native to Austria which have a similar physical appearance (Figure 1) and occur in similar habitats (Tables 1, 2). Each study species was shown by one photograph. To maximise comparability among species, photos were selected to show one adult individual of the study species (for mammals) or a population in full flower (for plants). Moreover, we selected photos that show species in similar situations (Figure 1).

Scope and questions of the survey

Perception of species

For every study species pair, the species photos were shown together with six questions which referred to the attitude of the survey participant towards the species.

Invasive alien species	**Native species**
a) Common Milkweed (Asclepias syriaca)	*b) White Swallow-Wort (Vincetoxicum hirundinaria)*
c) Himalayan Balsam (Impatiens glandulifera)	*d) Touch-me-not-Balsam (Impatiens noli-tangere)*
e) Raccoon Dog (Nyctereutes procyonoides)	*f) Red Fox (Vulpes vulpes)*
g) Raccoon (Procyon lotor)	*h) Beech Marten (Martes foina)*

Figure 1. Photos of the four pairs of native versus invasive alien study species used in the online survey. All photos are from Wikimedia Commons **a** Аимаина хикари **b** H. Zell **c** Donald Hobern **d** Malte **e** I. Pkuczynski **f** http://www.nps.gov/acad/photos/redfox.htm [Public domain] **g** Bastique **h** Zefram.

Table 1. Overview of the distribution, region of origin, first records and habitat affiliation of the invasive alien species of the survey (Essl and Rabitsch 2002; Umweltbundesamt 2019).

	Common Milkweed (*Asclepias syriaca*)	**Himalayan Balsam (*Impatiens glandulifera*)**	**Raccoon Dog (*Nyctereutes procyonoides*)**	**Raccoon (*Procyon lotor*)**
Origin	North America	India, Himalaya	Siberia, Ussuri, Manchuria, Korea, Japan	North and Central America
Habitat	ruderal slopes, roadsides, fallows	riversides, floodplains, ruderal plains, wet fallows	broadleaf and mixed forests, near waterbodies	wet broadleaf forests, near waterbodies, near settlements
Distribution in Austria	Vienna, Lower Austria, Upper Austria, Styria, Burgenland, Carinthia	All of Austria	Lower Austria, Upper Austria, Styria, Burgenland, Salzburg	Vienna, Lower Austria, Upper Austria, Styria, Carinthia, Vorarlberg, Salzburg
Ecological impacts	displacement of native plants; overgrowing of large areas; high spreading	displacement of native plants (riverside vegetation); overgrowing of large areas; high spreading	predation of molluscs, insects and amphibians; transmitter of diseases	no detailed data, predation of bird nests, amphibians, reptilians and fish; transmitter of diseases
First record in Austria	unknown	1898	1963	1974

Table 2. Overview of the distribution and habitat affiliation of the native species of the survey (Bellmann 2015; Fischer et al. 2005).

	White Swallow-Wort (*Vincetoxicum hirundinaria*)	**Touch-me-not-Balsam (*Impatiens noli-tangere*)**	**Red fox (*Vulpes vulpes*)**	**Beech Marten (*Martes foina*)**
Habitat	dry grasslands, open forests	riversides, floodplains, tall herb vegetation, broadleaf and mixed forests	cultural landscapes, settlements	parks, gardens, settlements, cultural landscapes
Distribution in Austria	widespread	widespread	widespread	widespread

Management methods

For each study species, a list of different management methods was presented. The participants were asked to assess the acceptance of these management methods and if there is a need to reduce or halt the spread of the species. The questions and the answer options were identical for mammal and vascular plant species.

The management methods presented were chosen according to Article 19 of Regulation (EU) no.1143/2014. As stated in the Regulation, the management option selection consists of "lethal and non-lethal physical, chemical and biological actions aimed at the eradication, population control or containment of a population of an invasive alien species" (European Parliament 2014). In addition, questions referring to relevant laws (e.g. EU IAS regulation) were included.

Species knowledge

The eight study species were shown and the participants were asked to specify for each species if it was native or invasive alien.

Topic relevance

First, the participants were asked to give an assessment of the relevance of alien species in general and their management for Austria. Subsequently, the contribution of different stakeholders (EU, national and regional governments, NGOs, farmers, foresters, hunters, gardeners, landscape architects) to IAS management was asked (five-point verbal unipolar scale, ranging from no agreement to strong agreement (Raab-Steiner and Benesch 2018)).

Awareness of EU IAS policies

As Regulation (EU) no. 1143/2014 is the cornerstone of European IAS policies, participants were asked about their awareness of this Regulation and if they believed that IAS policies indeed required an EU regulation. For these purposes, participants were asked to assess statements on the usefulness of the EU IAS legislation. Participants had the choice between "agree", "no answer" and "disagree".

Personal data

The following personal data of the participant was recorded: gender, age, size of municipality of residence, home country and highest completed level of education. These personal data were used to assess the characteristics of the sample of survey participants. These questions were presented with single-choice options.

Focal stakeholder groups

We selected participants from three pre-defined stakeholder groups. To do so, participants were asked to characterise themselves at the beginning of the survey as members of one of the following three stakeholder groups: i) Nature-Users (farmers, hunters, gardeners, landscape architects, foresters), b) Nature-Experts (biologists, environmental-NGO-staff, nature-conservationists) and c) General public (participants who do not belong to the above-mentioned groups). The same set of questions was used for all three groups of participants.

Survey execution

For the online survey, the software Limesurvey 3.15 (https://www.limesurvey.org/) was used. It was installed on a server provided by the University of Vienna. The survey was conducted in German, because the main target groups were people living in Austria. The survey was open from 5 November to 25 December 2018. The following media

outlets were used for distributing the survey: Facebook (https://www.facebook.com/), WhatsApp and E-mail. As the convenience sampling method was used, it was considered acceptable to choose specific media channels to reach potential participants of the different stakeholder groups. On Facebook, for example, the link to the survey was posted in different "groups" for Austrian biologists. A reminder was sent via E-mail and posted on the used social media two weeks after the first call. Several participants were contacted directly via E-mail or chat message.

Data analysis

In total, 967 participants started the survey, of which 239 (24.8%) fully completed it. Non-completed surveys (n = 728) were excluded from the analysis. For analyses, we pooled the responses per person (by calculating the arithmetic mean) across the two study species in each of the four focal groups "native plant species", "native mammal species", "invasive alien plant species" and "invasive alien mammal species".

We used the Kruskal-Wallis-Test (Kruskal and Wallis 1952) for ordinal scaled and independent samples to identify significant differences among the answers of the stakeholder groups. It was applied for the questions on perceptions and management methods and conducted for each of the four species groups (i.e. native plants, invasive alien plants, native animals and invasive alien animals). Thus, the independent variable was the stakeholder group and the dependent variables were the coded answers for the species groups. Post-hoc, Dunn's pairwise tests (Dunn 1961) were carried out to assess the differences for the three pairs of stakeholder groups (i.e. nature users versus nature experts, nature users versus general public and nature experts versus general public) and adjusted using the Bonferroni correction (Bonferroni 1935, 1936).

We used Wilcoxon-Tests (Raab-Steiner and Benesch 2018) to test for significant differences among species groups, i.e. native plants versus invasive alien plants and native animals versus invasive alien animals within stakeholder groups. These were applied for questions on species perception and management method acceptance. Further, we tested for significant differences among responses of the three stakeholder groups. Spearman's Rho (Daniel 1990; Raab-Steiner and Benesch 2018) was used to assess correlations between species perception and the acceptance of management methods. For nominal variables, such as the questions regarding the EU IAS regulation and relevance of IAS, X^2-tests (Pearson 1900) and Fisher's exact tests (for small case numbers) (Fisher 1970) were used to test for significant differences across stakeholder groups.

Results

Distribution of participants across stakeholder groups

Of the 239 respondents who had provided full replies, 128 participants (53.5%) were members of the "general public" (GP), 20 (8.4%) "nature users" (NU) and 91 (38.1%)

"nature experts" (NE). Unless otherwise noted, these are the sample sizes used in the analyses. The majority (72%) of the participants were younger than 30 years, 63% were female and 45% lived in a large city with more than 100,000 inhabitants. This was particularly the case for the "general public" stakeholder group. Other studies on the perception of IAS have shown similar demographic patterns (Bremner and Park 2007; Lindemann-Matthies 2016).

Survey results

Knowledge of native/invasive alien status

The assignment of the species, i.e. whether they are native or invasive alien species, was similar among the stakeholder groups (Figure 2). The majority of participants assigned the species correctly. The species assignment for mammals was correct more often than for plants, where for plants, the proportion of "I don't know" answers was 10 to 25%.

Perception of species and management method acceptance

The response on the perceived importance of the native species for ecosystem functioning in Austria was similar across all stakeholder groups. Interestingly, native mammals were rated to be more important for ecosystem functioning than any other species group (Figure 3A). The general public rated the importance of invasive alien mammals

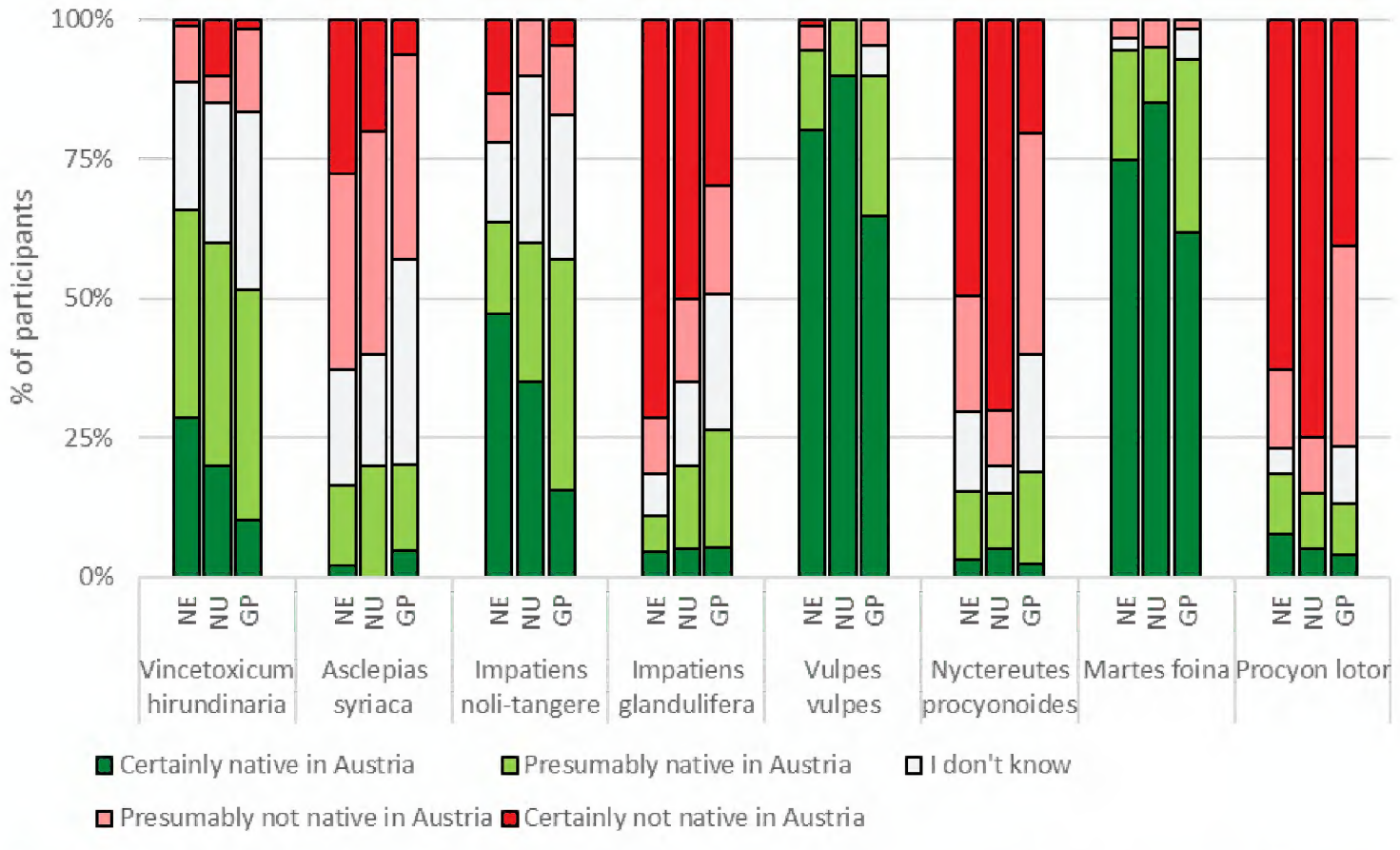

Figure 2. Participants' knowledge about the native / invasive alien status of the study species. Abbreviations: GP = general public; NU = nature users; NE = nature experts.

for ecosystem functioning significantly better than nature experts did (Dunn-Bonferroni: F = -2.54; *p = 0.033*). There were significant differences between native and invasive alien plants within each stakeholder group as to the species' importance in ecosystem function (Wilcoxon tests: NE: F = -6.46; *p = < 0.001*, NU: F = -1.96; *p = 0.05*, GP: F = -4.06; *p = < 0.001*). Similar results were obtained for mammals (Wilcoxon tests: NE: F = 7.31; *p = < 0.001*, NU: F = 3.73; *p = 0.004*, GP: F = 7.95; *p = < 0.001*).

The majority of the participants across the stakeholder groups rated all species in the study as aesthetic or very aesthetic. Mammal species' aesthetics were rated higher than plant species, but this difference was not significant (Figure 3B). There were no significant differences in the rating of the aesthetics species among the three stakeholder groups. The comparison of native versus invasive alien mammal species within stakeholder groups showed that invasive alien mammals were rated significantly lower than native ones (Wilcoxon test: NE: Z = -5.92; *p = < 0.001*, NU: Z = -2.91; *p = 0.004*, GP: Z = -4.35; *p = < 0.001*).

The question of whether the study species belongs to Austrian ecosystems was similar among all stakeholder groups. Furthermore, native species were more frequently assigned to Austrian ecosystems than alien species (Figure 3C). The general public's answers regarding whether alien mammal species belonged to Austrian ecosystems were significantly more positive than those of the other two stakeholder groups (Dunn-Bonferroni: NU: F = 3.28; *p = 0.003, NE: F = 3.81*; *p = < 0.001*). The same was the case for alien plant species, but in this case, there is only a significant difference between nature experts and general public (Dunn-Bonferroni: F = 4.98; *p = < 0.001*). Within stakeholder groups, native versus invasive alien species and mammals versus plant species were rated significantly different (Figure 3D). However, the rating of native versus alien animal species was more distinct than those of native versus alien plant species.

The comparison across stakeholder groups showed that nature users had a significantly higher acceptance of clearing/shooting than the general public (Dunn-Bonferroni: IAS plants: F = 2.55; *p = 0.032*; *native mammals:* F = 3.79; *p = < 0.001*; *IAS mammals:* F = 4.95; *p = < 0.001*), except for native plants. The acceptance of shooting management of alien mammals varied among stakeholder groups (Kruskal-Wallis: F = 29.94; *p = < 0.001*) (Figure 3E). For nature experts, the acceptance level for lethal management showed significant differences between native and invasive alien species (plants: Wilcoxon: F = 5.39; *p = < 0.001*, mammals: Wilcoxon: F = 4.89; *p = < 0.001*). For nature users, clearing of invasive alien mammals was significantly more accepted than for native mammals (Wilcoxon: F = 2.37; *p = 0.018*). For the general public, clearing of invasive alien plants was significantly more accepted than for native plants (Wilcoxon: F = 3.65; *p = < 0.001*).

Nature experts' assessment of the study species belonging to Austrian landscapes (Figure 3B) and of clearing/shooting as the management method (Figure 3D) of alien species was significantly negatively correlated (mammals: Spearman-Rho = -0.56; *p = < 0.001*, plants: Spearman-Rho = -0.55; *p = < 0.001*). Participants had a lower acceptance for clearing/shooting when they assessed the species as belonging to Austrian ecosystems (Spearman-Rho = -0.39; p = *< 0.001*), except for native mammal species, where participants had a broad acceptance of this control method (Spearman-Rho =

0.17; $p = 0.106$). The answers to these questions by the other stakeholder groups (i.e. general public, nature users) were not significantly correlated.

Most of the participants assessed killing by chemical agents as 'rather not' to 'not acceptable' (Figure 3E). Across stakeholder groups, for alien mammal species, nature users had a significantly higher acceptance of this method than the other two groups

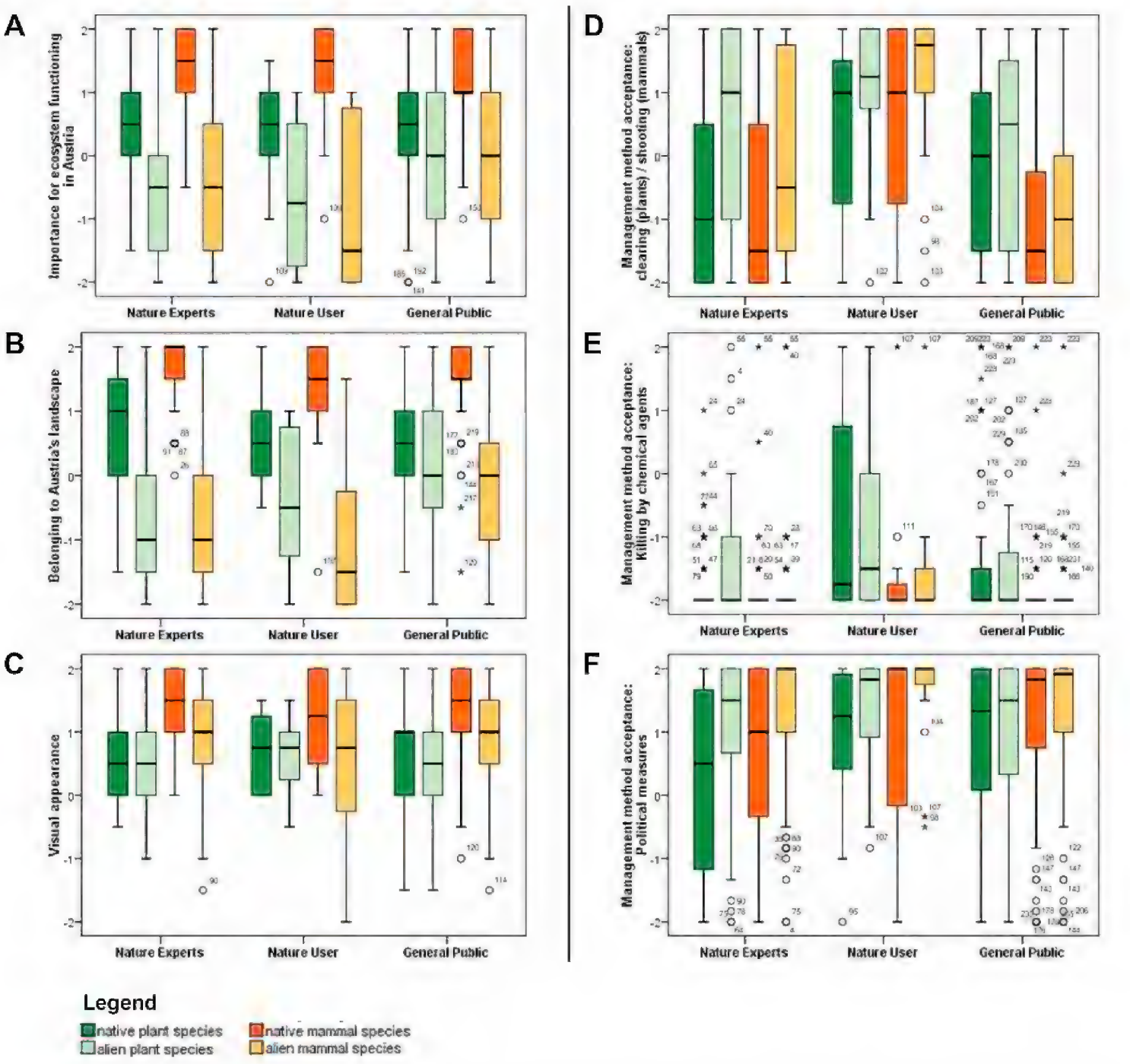

Figure 3. A The perceived importance of native and invasive alien plant and mammal species for ecosystem functioning in Austria rated by the three stakeholder groups. Scale: -2 (very unimportant) to 2 (very important). **B** The physical appearance of native and invasive alien plant and mammal species rated by the three stakeholder groups. Scale: -2 (not aesthetic) to 2 (very aesthetic). **C** Does the species belonging to Austrian ecosystems as rated by the three stakeholder groups. Scale: -2 (No) to 2 (Yes). **D** Assessment of the acceptance of the management method "clearing (plants)/shooting (mammals)". Scale: -2 (not acceptable) to 2 (very acceptable). **E** Assessment of the acceptance of the management method "killing by chemical agents". Scale: -2 (not acceptable) to 2 (very acceptable). **F** Assessment of the acceptance of the management method "legal measures" (e.g. prohibition of keeping, trading and releasing, import bans). Scale: -2 (not acceptable) to 2 (very acceptable). For significance tests, see main text.

(Kruskal-Wallis: F = 10.91; p = *0.004*). The same finding applied to native mammal species, but there, the only significant difference was between nature users and the general public (Dunn-Bonferroni: F = 2.42; p = *0.046*). The answers of the stakeholder groups regarding native plant species showed significant differences between nature users and nature experts (Dunn-Bonferroni: F = 2.90; p = *0.011*).

Legal measures (e.g. prevention of introduction, prohibition of keeping, trading and releasing, import bans) for IAS were highly acceptable as a management method among all stakeholder groups (Figure 3F). However, nature experts' acceptance of these measures for native plant (Dunn-Bonferroni: F = 3.21; p = *0.004*) and mammal species (Dunn-Bonferroni: F = 2.85; p = *0.013*) was significantly lower than the general public's acceptance. The comparison of native versus invasive alien plant species within stakeholder groups showed that the acceptance for these measures was significantly higher for invasive alien plants (Wilcoxon tests: NE: F = 5.48; p = < *0.001*, NU: F = 1.96; p = *0.05*, GP: F = 2.93; p = *0.003*). The same result was found for mammals (Wilcoxon tests: NE: F = 4.69; p = < *0.001*, NU: F = 2.02; p = *0.043*, GP: F = 2.56; p = *0.01*).

Contribution of different institutions and stakeholders to IAS management

Generally, the three stakeholder groups had similar perceptions in their assessment of different stakeholders' contribution to IAS management (Figure 4). Nevertheless, some significant differences were detected. Especially outstanding were "nature users" (i.e. farmers, hunters), who significantly (Kruskal-Wallis: F = 2.01; p = < *0.001*) at-

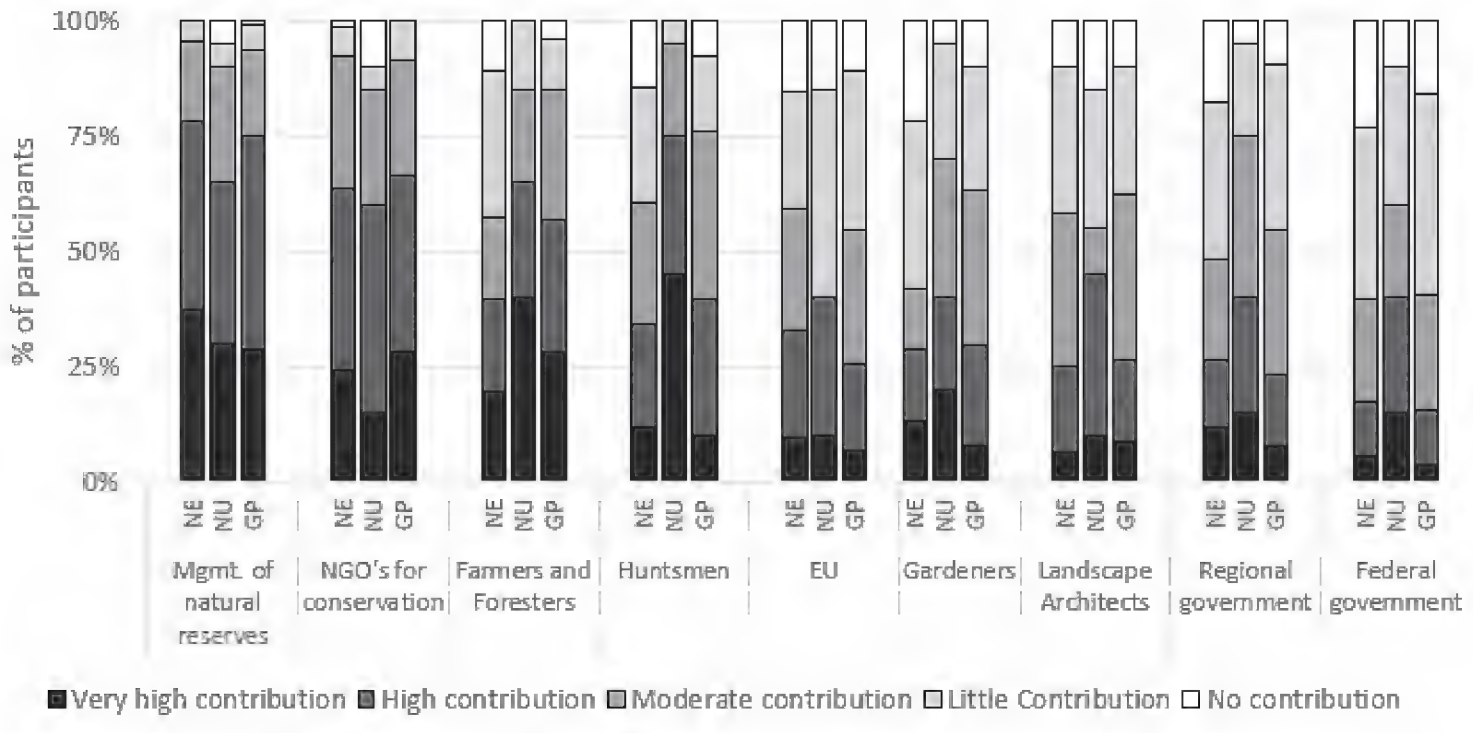

Figure 4. Assessment of the stakeholder groups opinion of the contribution to IAS management by different stakeholders. Differences were tested for significance by X^2-test and Fisher's exact tests – no differences detected. Significant differences between NU and NE were found in the "Farmers and Foresters" group (Kruskal-Wallis: F = 2.01; p = < 0.001). Abbreviations: GU = general public; NU = nature users; NE = nature experts.

tested themselves a higher contribution to IAS management than nature experts did. Taken together, these results show that the participants assumed that dedicated institutions (e.g. NGO's and conservation area-managers) have the largest contribution to IAS management, while the contribution of political decision-makers is minor.

Assessment of the relevance of invasive alien species in Austria and EU policies

More than 75% of all participants replied that IAS and their management are 'a rather' to 'very relevant' topic for Austria and that it is "rather to very important" to manage them at EU level (Figure 5). However, more than 50% of the respondents of all stakeholder groups were not aware of the EU IAS Regulation. In particular, members of the general public were significantly less aware of this Regulation than the other two groups (X^2-test: F = 25.06; p = < *0.001*).

The results regarding the specific statements on EU IAS actions show that an overwhelming majority of participants agreed that IAS affect biodiversity in Europe (Figure 6). They disagreed the most with the statement that IAS were not a threat in EU countries. The majority of survey participants of all three stakeholder groups agreed that EU coordination in this field is advantageous and that coordinated activities for all EU member states were more efficient. Overall, the answers of the different stakeholder groups were quite similar, except for the answers of nature experts to the statement "every country should decide autonomously", where the agreement was significantly (X^2-test: F = 14.13; p = *0.007*) lower than for nature users.

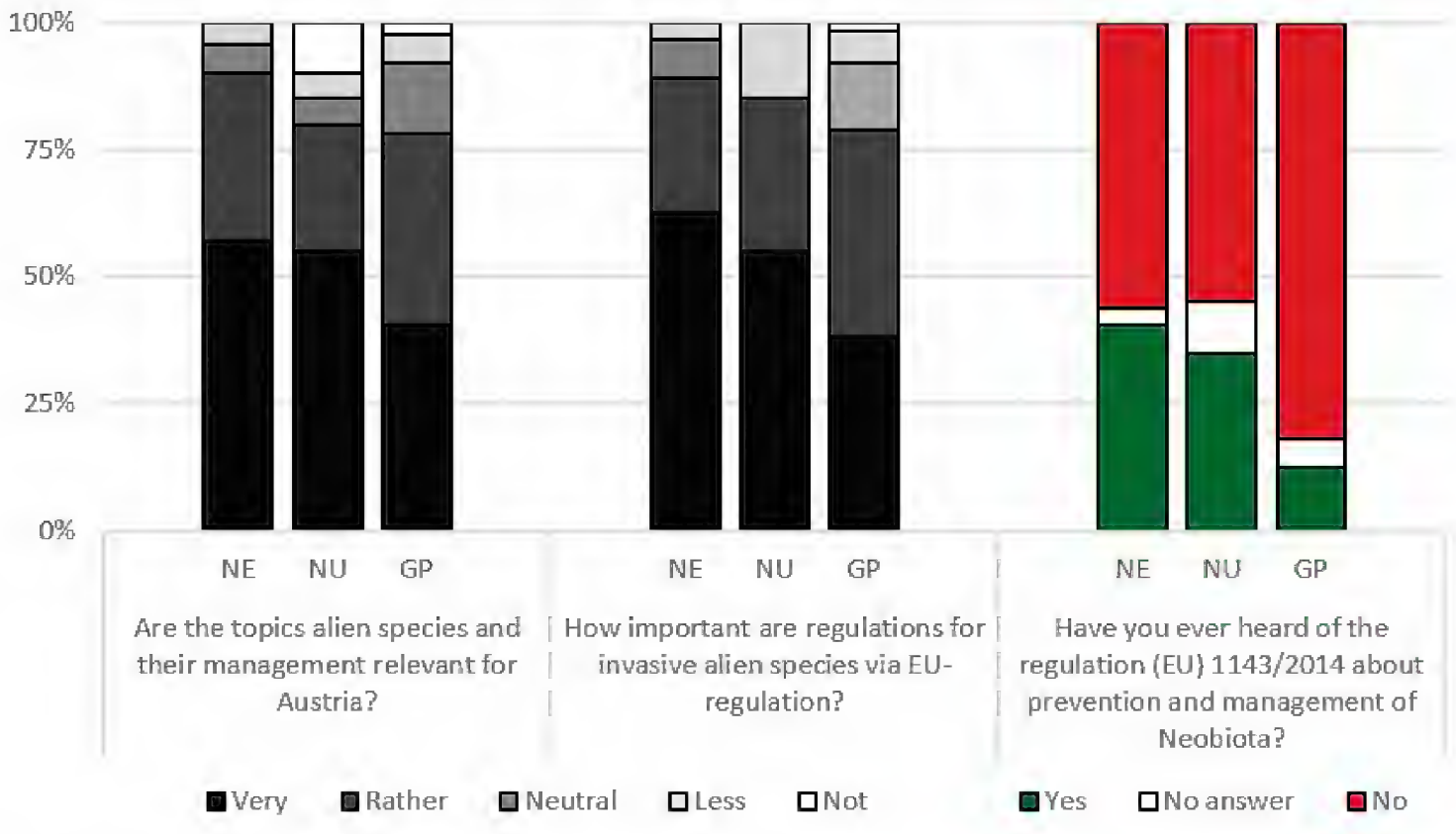

Figure 5. Relevance and awareness of the IAS topic and the EU regulation. Abbreviations: GP = general public; NU = nature users; NE = nature experts.

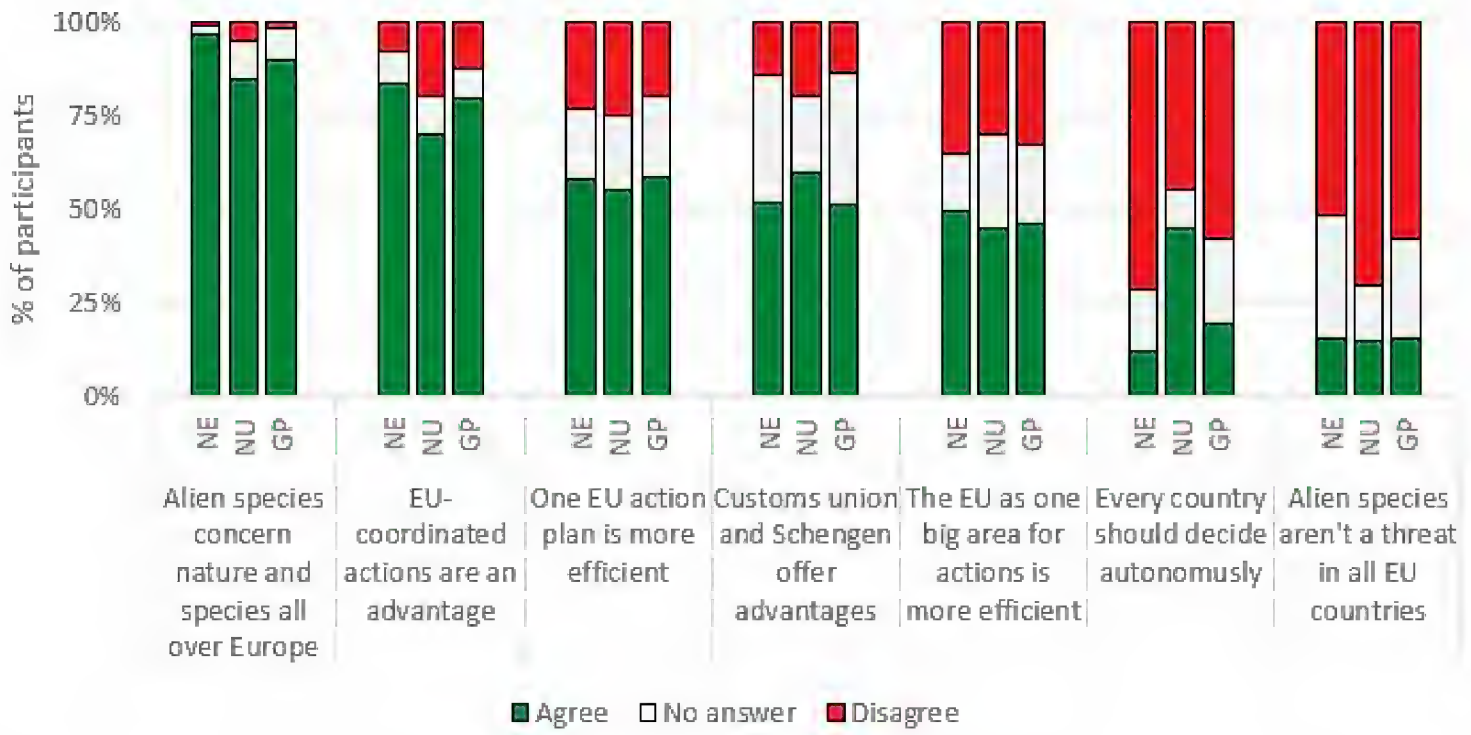

Figure 6. The importance of different IAS management and policy activities on the EU level for different stakeholder groups. Abbreviations: GP = general public; NU = nature users; NE = nature experts.

Discussion

Perception of species and acceptance of management methods

Since perceptions of IAS are diverse (García-Llorente et al. 2008) and some control methods can create highly emotional responses (Australian Academy of Science 2018; Bertolino and Genovesi 2003), it is necessary to include social perspectives into IAS research, management and policies (Kapitza et al. 2019). This study should encourage further research projects to raise mutual understanding for the views of the general public, nature users and conservation experts to achieve a broader consensus for IAS control measure.

The participants of this survey had a distinct knowledge about the origin of the species and the assessments of their ecological function and their belonging to Austrian ecosystems followed this pattern. Native species were more positively connoted than invasive alien ones across all three stakeholder groups. The physical appearance assessment showed that all species were rated as "aesthetic" (German: "optisch ansprechend bzw. schön") or "very aesthetic" (German: "optisch sehr ansprechend bzw. sehr schön") by the majority of the participants. In this context, we were particularly interested to test if there is a significant relationship between the aesthetic appearance of species and the acceptance of different management methods. Previous studies have shown that acceptability of management measures often reflect aesthetic motivations (Verbrugge et al. 2013; Fischer et al. 2014) but also that information about the impact of IAS lowers the aesthetic attraction and raises the acceptance of management measures (Junge et al. 2019). However, as the rating of the physical appearance of the study species was similar among the stakeholder groups, it was not possible to identify significant relationships with the assessment of management methods.

We found a significant correlation between the assessment of study species as belonging to Austrian ecosystems and the acceptance of lethal management. When a species was considered to be an invasive alien species, acceptance of lethal methods was significantly higher. This result confirms other studies that had found similar results for the acceptance of eradication measures for IAS with negative impacts on the environment (García-Llorente et al. 2008; Verbrugge et al. 2013; Fischer et al. 2014; Lewis et al. 2019). However, it is important to note that the acceptance of lethal management differs between stakeholder groups, especially for the mammal species of this study. Nature experts follow the described native/invasive alien-pattern, confirming previous studies which have shown that better knowledge of IAS increases the acceptance of control measures (Bremner and Park 2007). Further, nature users had a significantly higher acceptance of lethal methods than the general public. For example, this corresponds to the situation in New South Wales, where the general public opposed the killing of Brumbies (*Equus callabus*), while hunters and scientists supported it (NSW Government Office of Environment & Heritage 2016; NSW Threatened Species Scientific Committee 2016; Australian Academy of Science 2018; Parliament of New South Wales 2018). Similarly, Verbrugge et al. (2013) and Jaric et al. (2020) report that people are less likely to support eradication when it concerns a charismatic, aesthetically or otherwise attractive animal species, even if there is scientific evidence that it is invasive. Using the example of *Anser albifrons* and *Branta leucopsis* management on Islay (Scotland), Hanley et al. (2003) found that the willingness to pay for management measures was significantly reduced when lethal methods were included. In an expert survey on alien donkey control on Bonaire (Caribbean Netherlands), lethal methods were considered as least acceptable and fencing as most acceptable (Roberts et al. 2018). Estévez et al. (2015) stated that "value systems and risk perceptions are understood as the fundamental basis of discrepancies" among the different stakeholders. These value systems include aesthetic attraction and emotional bonding, as well as the utilisation of nature.

The overall rejection of chemicals (herbicides, poison pellets) as a method for killing invasive alien species was already shown in other studies (Verbrugge et al. 2013), where for mammals in particular, acceptance for this method is low. Nature users expressed a significantly higher acceptance of this method, but it was still low. Generally, nature users had higher acceptance levels for all management methods than the other two stakeholder groups. This may reflect the fact that members of this stakeholder group are economically directly dependent on extracting natural resources and thus negative impacts caused by IAS might be more evident for them. It has been shown that personal interests (e.g. economic interests) influence opinion held on specific alien species (Shackleton et al. 2019a, b). Further, García-Llorente et al. (2008) showed that conservation professionals and local citizens of the Donana region (SW Spain) considered effects of IAS to the local economy (while tourists considered the effects on threatened species) as economic incentives for IAS eradication. In a Swiss study, experts and members of the general public attribute a higher priority to ecological than to economic aspects (Junge et al. 2019). Further, utilisation can also be one value that influences the attitude of people towards nature (Estévez et al. 2015).

Since approximately 86% of the territory of Austria is used for agriculture or forestry (Statistik Austria 2016), nature users are the dominant social actor in environmental management. In our study, nature experts did not consider nature users as important for IAS management, although other studies have shown that nature users' knowledge and goals often do not differ fundamentally from their own (Badgley 2003). Badgley (2003) stated that "farmers can benefit from conservationists as advocates for farming practices that raise the quality of the landscape for farmers and for biodiversity and conservationists can benefit from farmers who enhance the ecological value of working landscapes for more native species". Therefore, we consider it crucial for nature users and nature experts to appraise each other's values and to work jointly to address problems caused by IAS.

In the disputed cases of failed grey squirrel eradication in Italy (Bertolino and Genovesi 2003) and Brumby eradication in Australia (NSW Threatened Species Scientific Committee 2016), animal right groups rejected lethal methods and established strong opposition to halt planned management measures. According to Crowley et al. (2017), conflicts concerning IAS management are not always avoidable, but taking the socioecological context into account, they can be minimised. For Perry and Perry (2008), the solution is communication and increasing understanding between "managers" (i.e. nature users, nature experts) and animal rights groups. Caravaggi et al. (2017) came to similar conclusions after surveying the opinions on lethal methods for IAS management of members and non-members of rural interest groups in Northern Ireland. Perry and Perry (2008) argue that managers should be more open to exploring non-lethal alternatives and animal rights groups should understand the motivation behind eradication attempts and be more involved in providing the extra funding necessary to support preventative measures and that "cooperation between the two groups is possible and desirable and that prevention of species invasion is an obvious area in which to begin." Our survey did not sample the opinions of animal rights activists, but it would be interesting to include them in a future study. Legal measures (as provided by Article 7 of the EU IAS Regulation 1143/2014) were received favourably by all three stakeholder groups. Our interpretation is that these measures are neither lethal for IAS nor do they affect the daily life of a significant proportion of participants, so ethical conflicts are likely perceived to be minor.

Across stakeholder groups, the participants' knowledge whether survey species were native or invasive alien species was very high. The majority of the participants assigned the species to the correct category. As the level of knowledge affects understanding and behaviour of people (Shackleton et al. 2019b), as well as perception of IAS (Eiswerth et al. 2011; Vaz et al. 2019) and control measures (Bremner and Park 2007; Junge et al. 2019), this may have had an influence on the present assessment of the perception parameters, as well as the management method acceptance parameters.

Relevance of EU IAS policies

Although the contribution of the EU to IAS management is rated low (nearly 50% responded that there is currently little or no contribution by the EU) among all stake-

holder groups, there is overwhelming support for more ambitious measures to be implemented at EU-level. The majority of the participants agreed with the advantages of IAS management organised and regulated by the EU. Thus, there is a high awareness of IAS and the survey participants are aware of the advantages of tackling this problem on a European level. For comparison, in a Swiss study only 40% of the participants belonging to the general public-stakeholder group were aware of the term invasive alien species (Junge et al. 2019).

Representativeness of this survey

This online survey used the convenience sampling method, i.e. the survey was open to everyone interested as long as (s)he lives in Austria. This approach is useful and widely used in cases when the basic sample size is unknown or very large, as is the case for the three stakeholder groups in this survey (Harvey et al. 2016; Lindemann-Matthies 2016). However, this approach comes with some limitations that have to be kept in mind when interpreting the results. First of all, it is unknown to what extent participants of the survey are fully representative for the respective stakeholder group, as biases, such as willingness to participate or basic knowledge of the existence of the survey, might be relevant (Etikan 2016). Secondly, sample sizes of the stakeholder groups differ substantially – as is the case in our survey with sample sizes varying between 20 (nature users) and 128 (general public). Finally, the substantial number of not-completed surveys may be associated with certain personal preferences which may also introduce specific biases in the results.

When distributing the survey, we used a broad set of communication channels for spreading the survey widely and thus reaching out to diverse audiences. In addition, the personal information of participants revealed that while some social strata (e.g. young urban populations) are somewhat over-represented, the distribution among basic demographic and personal parameters is relatively closely reflecting the Austrian population composition (Suppl. material 2: Table S1). Thus, we conclude that this survey provides important insights into the perception of native and invasive alien species in Austria. Still, it is clear that full representativeness cannot be achieved with convenience sampling.

Conclusions

Since the majority of the participants agreed that IAS concern Austria and that there is a need to regulate them on a European level, this study indicates substantial awareness of the topic. The high level of knowledge, whether it is a native or an invasive alien species, as well as the perception parameters in the survey, emphasise this finding. As other studies have shown, one key to success for raising the general public's awareness and support for IAS control measures is education and knowledge transfer (Bremner and Park 2007; Eiswerth et al. 2011; Junge et al. 2019). However, this can also cause

polarisation and trigger conflicts (Crowley et al. 2017) and therefore it has to be done wisely. An improved understanding of the acceptance of management methods among stakeholder groups is also crucial for avoiding future conflicts.

Acknowledgements

We are highly grateful for all participants of the survey. FE appreciates funding by the Austrian Science Foundation FWF (grant I 3757-B29). We are grateful for helpful suggestions by Giuseppe Brundu and Ross Shackleton and the Handling Editor, Llewellyn Foxcroft.

References

Australian Academy of Science (2018) Open Letter to John Barilaro. https://www.science.org.au/files/userfiles/support/documents/letter-aas-jb-re-kosciuszko-wild-horse-heritage-bill-2018.pdf [Accessed 10 January 2019]

Badgley C (2003) The farmer as conservationist. American Journal of Alternative Agriculture 18: 206–212. https://doi.org/10.1079/AJAA200352

Bellmann H (2015) Der große Kosmos-Naturführer Tiere und Pflanzen. Kosmos-Naturführer, Kosmos.

Bertolino S, Genovesi P (2003) Spread and attempted eradication of the grey squirrel (Sciurus carolinensis) in Italy, and consequences for the red squirrel (Sciurus vulgaris) in Eurasia. Biological Conservation 109: 351–358. https://doi.org/10.1016/S0006-3207(02)00161-1

Bethlehem JG, Biffignandi S (2012) Handbook of web surveys. Wiley handbooks in survey methodology. Wiley, Hoboken N.J. https://doi.org/10.1002/9781118121757

Bonferroni CE (1935) Il calcolo delle assicurazioni su gruppi di teste. Studi in Onore del Professore Salvatore Ortu Carboni: 13–60.

Bonferroni CE (1936) Teoria statistica delle classi e calcolo delle probabilità. Pubblicazioni del R Istituto Superiore di Scienze Economiche e Commerciali di Firenze: 3–62.

Bremner A, Park K (2007) Public attitudes to the management of invasive non-native species in Scotland. Biological Conservation 139: 306–314. https://doi.org/10.1016/j.biocon.2007.07.005

Caravaggi A, Montgomery I, Reid N (2017) Management and control of invasive brown hares (*Lepus europaeus*): contrasting attitudes of selected environmental stakeholders and the wider rural community. Biology and Environment: Proceedings of the Royal Irish Academy 117B: 1–53. https://doi.org/10.3318/bioe.2017.08

Caro TM, Girling S (2010) Conservation by Proxy: Indicator, Umbrella, Keystone, Flagship, and Other Surrogate Species. Island Press, Washington.

Crowley SL, Hinchliffe S, McDonald RA (2017) Conflict in invasive species management. Frontiers in Ecology and the Environment 15: 133–141. https://doi.org/10.1002/fee.1471

Daniel WW (1990) Applied nonparametric statistics (2nd ed.). The Duxbury advanced series in statistics and decision sciences. PWS-KENT, Boston.

Dunn OJ (1961) Multiple Comparisons Among Means. Journal of the American Statistical Association 56: 1–52. https://doi.org/10.2307/2282330

Eiswerth ME, Yen ST, van Kooten GC (2011) Factors determining awareness and knowledge of aquatic invasive species. Ecological Economics 70: 1672–1679. https://doi.org/10.1016/j.ecolecon.2011.04.012

Essl F, Rabitsch W (2002) Neobiota in Österreich. Umweltbundesamt, Wien.

Essl F, Bacher S, Genovesi P, Hulme PE, Jeschke JM, Katsanevakis S, Kowarik I, Kühn I, Pyšek P, Rabitsch W, Schindler S, van Kleunen M, Vilà M, Wilson JRU, Richardson DM (2018) Which Taxa Are Alien? Criteria, Applications, and Uncertainties. BioScience 68: 496–509. https://doi.org/10.1093/biosci/biy057

Estévez RA, Anderson CB, Pizarro JC, Burgman MA (2015) Clarifying values, risk perceptions, and attitudes to resolve or avoid social conflicts in invasive species management. Conservation Biology 29: 19–30. https://doi.org/10.1111/cobi.12359

Etikan I (2016) Comparison of Convenience Sampling and Purposive Sampling. American Journal of Theoretical and Applied Statistics 5: 1–1. https://doi.org/10.11648/j.ajtas.20160501.11

European Commission (2011) Our life insurance, our natural capital: an EU Biodiversity Strategy to 2020. (COM(2011) 244).

European Commission (2016) Commission Implementing Regulation (EU) 2016/1141 of 13 July 2016 adopting a list of invasive alien species of Union concern pursuant to Regulation (EU) No 1143/2014 of the European Parliament and of the Council. C/2016/4295.

European Commission (2019) List of Invasive Alien Species of Union concern. https://ec.europa.eu/environment/nature/invasivealien/list/index_en.htm [Accessed 15 August 2019]

European Parliament (2014) Regulation (EU) No 1143/2014 of the European Parliament and of the Council of 22 October 2014 on the prevention and management of the introduction and spread of invasive alien species. https://eur-lex.europa.eu/eli/reg/2014/1143/oj [Accessed 18 April 2019]

Fischer A, Selge S, van der Wal R, Larson BMH (2014) The public and professionals reason similarly about the management of non-native invasive species: a quantitative investigation of the relationship between beliefs and attitudes. PloS ONE 9: e105495. https://doi.org/10.1371/journal.pone.0105495

Fischer MA, Adler W, Oswald K (2005) Exkursionsflora für Österreich, Liechtenstein und Südtirol: Bestimmungsbuch für alle in der Republik Österreich, in der Autonomen Provinz Bozen, 2., verb. u. erw. Aufl. der "Exkursionsflora von Österreich". OÖ Landesmuseum, Linz.

Fisher RA (1970) Statistical methods for research workers (14th ed., rev. and enl.). Oliver & Boyd, Edinburgh.

García-Llorente M, Martín-López B, González JA, Alcorlo P, Montes C (2008) Social perceptions of the impacts and benefits of invasive alien species: Implications for management. Biological Conservation 141: 2969–2983. https://doi.org/10.1016/j.biocon.2008.09.003

Hanley N, MacMillan D, Patterson I, Wright RE (2003) Economics and the design of nature conservation policy: a case study of wild goose conservation in Scotland using choice experiments. Animal Conservation 6: 123–129. https://doi.org/10.1017/S1367943003003160

Harvey RG, Perez L, Mazzotti FJ (2016) Not seeing is not believing: volunteer beliefs about Burmese pythons in Florida and implications for public participation in invasive species

removal. Journal of Environmental Planning and Management 59: 789–807. https://doi.org/10.1080/09640568.2015.1040489

Junge X, Hunziker M, Bauer N, Arnberger A, Olschewski R (2019) Invasive Alien Species in Switzerland: Awareness and Preferences of Experts and the Public. Environmental Management 63: 80–93. https://doi.org/10.1007/s00267-018-1115-5

Kapitza K, Zimmermann H, Martín-López B, Wehrden H von (2019) Research on the social perception of invasive species: a systematic literature review. Neobiota 43: 47–68. https://doi.org/10.3897/neobiota.43.31619

Kruskal WH, Wallis WA (1952) Use of Ranks in One-Criterion Variance Analysis. Journal of the American Statistical Association 47: 583–621. https://doi.org/10.1080/01621459.1952.10483441

Kueffer C (2017) Plant invasions in the Anthropocene. Science (New York, N.Y.) 358: 724–725. https://doi.org/10.1126/science.aao6371

Lewis CL, Granek EF, Nielsen-Pincus M (2019) Assessing local attitudes and perceptions of non-native species to inform management of novel ecosystems. Biological Invasions 21: 961–982. https://doi.org/10.1007/s10530-018-1875-0

Likert R (1932) A technique for the measurement of attitudes. Archives of Psychology: 5–55.

Lindemann-Matthies P (2016) Beasts or beauties? Laypersons' perception of invasive alien plant species in Switzerland and attitudes towards their management. Neobiota 29: 15–33. https://doi.org/10.3897/neobiota.29.5786

NSW Government Office of Environment & Heritage (2016) Final report of the Independent Technical Reference Group, Supplementary to the Kosciuszko National Park Wild Horse Management Plan.

NSW Threatened Species Scientific Committee (2016) Habitat degradation and loss by Feral Horses: Preliminary Determination.

Parliament of New South Wales (2018) Kosciuszko Wild Horse Heritage Bill: Act No 24 of 2018 (GG No. 63, 22/06/2018, p. 3896). https://www.parliament.nsw.gov.au/bills/Pages/bill-details.aspx?pk=3518 [Accessed 10 January 2019]

Pearson K (1900) On the criterion that a given system of deviations from the probable in the case of a correlated system of variables is such that it can be reasonably supposed to have arisen from random sampling. The London, Edinburgh and Dublin Philosophical Magazine and Journal of Science 50: 157–175. https://doi.org/10.1080/14786440009463897

Perry D, Perry G (2008) Improving interactions between animal rights groups and conservation biologists. Conservation Biology 22: 27–35. https://doi.org/10.1111/j.1523-1739.2007.00845.x

Raab-Steiner E, Benesch M (2018) Der Fragebogen: Von der Forschungsidee zur SPSS-Auswertung, 5., aktualisierte und überarbeitete Auflage. UTB, Schlüsselkompetenzen. facultas, Wien.

Roberts M, Cresswell W, Hanley N (2018) Prioritising invasive species control actions: evaluating effectiveness, costs, willingness to pay and social acceptance. Ecological Economics 152: 1–8. https://doi.org/10.1016/j.ecolecon.2018.05.027

Roy HE, Bacher S, Essl F, Adriaens T, Aldridge DC, Bishop JDD, Blackburn TM, Branquart E, Brodie J, Carboneras C, Cottier-Cook EJ, Copp GH, Dean HJ, Eilenberg J, Gallardo B, Garcia M, García-Berthou E, Genovesi P, Hulme PE, Kenis M, Kerckhof F, Kettunen M, Minchin D, Nentwig W, Nieto A, Pergl J, Pescott OL, Peyton JM, Preda C, Roques A, Rorke SL, Scalera R, Schindler S, Schönrogge K, Sewell J, Solarz W, Stewart AJA, Tricarico E, Vanderhoeven S, van der Velde G, Vilà M, Wood CA, Zenetos A, Rabitsch W (2019) Developing a list of invasive alien species likely to threaten biodiversity and ecosystems in the European Union. Global Change Biology 25: 1032–1048. https://doi.org/10.1111/gcb.14527

Saunders M, Lewis P, Thornhill A (2009) Research methods for business students (5th ed.). Financial Times Prentice Hall, Harlow.

Schnell R, Hill PB, Esser E (2018) Methoden der empirischen Sozialforschung, 11., überarbeitete Auflage. De Gruyter Studium. De Gruyter Oldenbourg, Berlin, Boston.

Shackleton RT, Richardson DM, Shackleton CM, Bennett B, Crowley SL, Dehnen-Schmutz K, Estévez RA, Fischer A, Kueffer C, Kull CA, Marchante E, Novoa A, Potgieter LJ, Vaas J, Vaz AS, Larson BMH (2019a) Explaining people's perceptions of invasive alien species: A conceptual framework. Journal of Environmental Management 229: 10–26. https://doi.org/10.1016/j.jenvman.2018.04.045

Shackleton RT, Larson BMH, Novoa A, Richardson DM, Kull CA (2019b) The human and social dimensions of invasion science and management. Journal of Environmental Management 229: 1–9. https://doi.org/10.1016/j.jenvman.2018.08.041

Statistik Austria (2016) Agrarstrukturerhebung: Land- und forstwirtschaftliche Betriebe und deren Gesamtfläche. https://www.statistik.at/web_de/statistiken/wirtschaft/land_und_forstwirtschaft/agrarstruktur_flaechen_ertraege/betriebsstruktur/index.html [Accessed 25 May 2019]

Umweltbundesamt (2019) Neobiota in Österreich. https://www.neobiota-austria.at [Accessed 9 July 2109]

Vaske JJ, Jacobs MH, Sijtsma MTJ (2011) Wildlife value orientations and demographics in The Netherlands. European Journal of Wildlife Research 57: 1179–1187. https://doi.org/10.1007/s10344-011-0531-0

Vaz AS, Ribeiro J, Honrado JP, Vicente JR (2019) Stakeholders' perceptions towards non-native acacias and implications for their management in Portugal. Forestry: An International Journal of Forest Research 229: 1–27. https://doi.org/10.1093/forestry/cpz060

Verbrugge LNH, van den Born RJG, Lenders HJR (2013) Exploring public perception of non-native species from a visions of nature perspective. Environmental Management 52: 1562–1573. https://doi.org/10.1007/s00267-013-0170-1

Vilà M, Espinar JL, Hejda M, Hulme PE, Jarošík V, Maron JL, Pergl J, Schaffner U, Sun Y, Pyšek P (2011) Ecological impacts of invasive alien plants: a meta-analysis of their effects on species, communities and ecosystems. Ecology Letters 14: 702–708. https://doi.org/10.1111/j.1461-0248.2011.01628.x

WHO (2005) Millennium Ecosystem Assessment: Health Synthesis.

Worboys G, Pulsford I (2013) Observations of Pest Horse Impacts in the Australian Alps.

Supplementary material 1

Text S1, S2
Authors: Raphael Höbart, Stefan Schindler, Franz Essl
Data type: text documents
Explanation note: **Text S1.** Original (German) version of the survey text. **Text S2.** Translated English version of the survey text.
Copyright notice: This dataset is made available under the Open Database License (http://opendatacommons.org/licenses/odbl/1.0/). The Open Database License (ODbL) is a license agreement intended to allow users to freely share, modify, and use this Dataset while maintaining this same freedom for others, provided that the original source and author(s) are credited.
Link: https://doi.org/10.3897/neobiota.58.51522.suppl1

Supplementary material 2

Table S1. Overview on demographic data of survey respondents
Authors: Raphael Höbart, Stefan Schindler, Franz Essl
Data type: statistical data
Copyright notice: This dataset is made available under the Open Database License (http://opendatacommons.org/licenses/odbl/1.0/). The Open Database License (ODbL) is a license agreement intended to allow users to freely share, modify, and use this Dataset while maintaining this same freedom for others, provided that the original source and author(s) are credited.
Link: https://doi.org/10.3897/neobiota.58.51522.suppl2